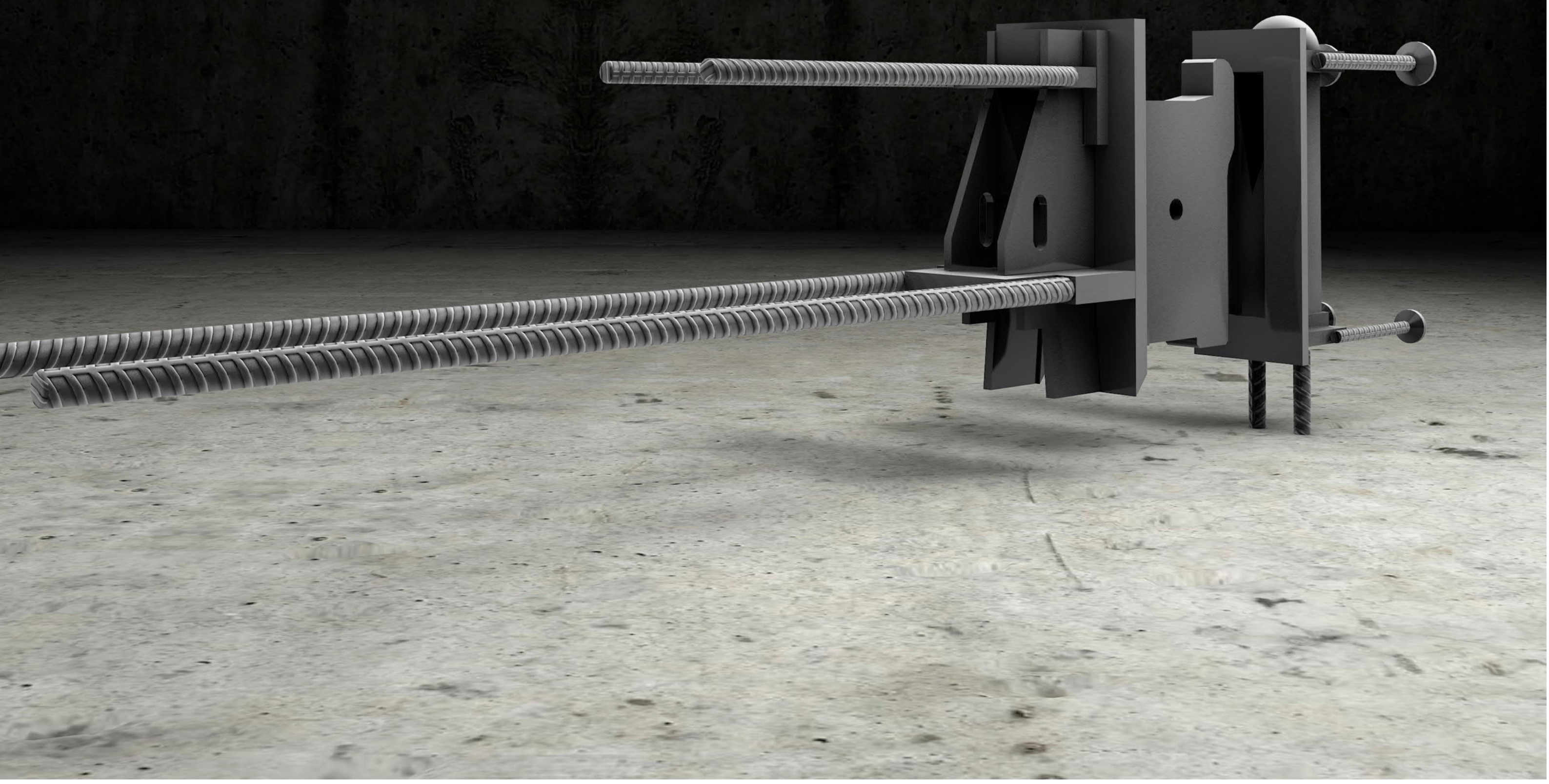

AEP® hidden bracket

User manual

Version 8/2021

AEP® hidden bracket

AEP® steel brackets are used to connect precast concrete beams to multi-storey columns or walls. The steel bracket transfers beam loads to the column or wall during installation and in final use of the structure. The bracket acts as a hinge joint allowing the beam to rotate longitudinally but transfers torsional loads from beam to column. The AEP® system makes it possible to use simple straight steel moulds since all steel parts are pocketed and hollow core concrete slabs can be installed without supporting the beam flange.

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1. PRODUCT DESCRIPTION

1.1 General

AEP steel brackets are used to connect precast concrete beams to multi-storey columns or walls. The steel bracket transfers beam loads to the column or wall during installation and in final use of the structure. The bracket acts as a hinge joint allowing the beam to rotate longitudinally but transfers torsional loads from beam to column. The AEP system makes it possible to use simple straight steel moulds since all steel parts are pocketed and hollow core concrete slabs can be installed without supporting the beam flange.

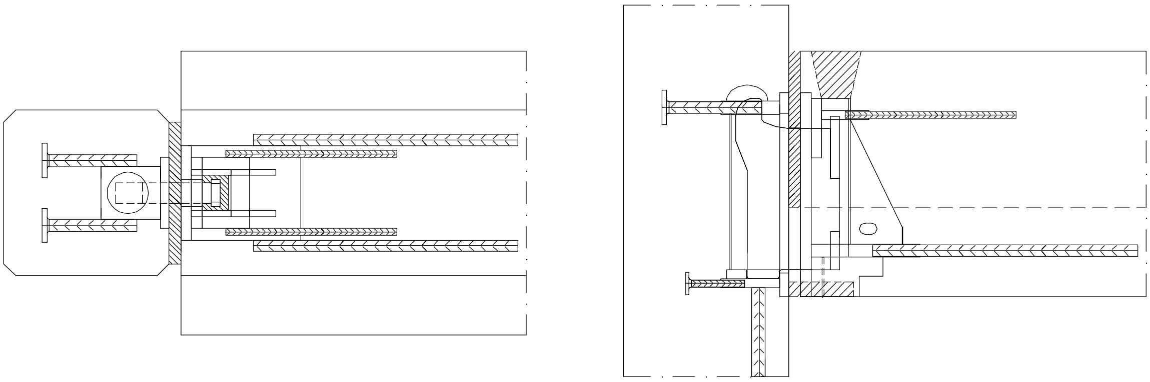


Fig 1. The AEP bracket system after installation

There is further a special bracket solution for beam-to-beam connections. One common frame structure in Finland is to use Anstar's steel-concrete composite A-Beams connected to precast concrete columns with AEP brackets.

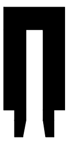
Table 1. AEP brackets and suitable A-Beams

	A200	A265	A320	A370	A400	A500
AEP400	■	■	■			
AEP600		■	■	■	■	
AEP800			■	■	■	■
AEP1100				■	■	■

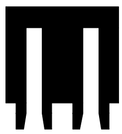
1.2 Product types

AEP steel brackets are manufactured in 6 different capacity classes. The number in the product code stands for the Eurocode capacity calculated with the Finnish National Annex. The standard design fits into small cross-sections. The twin brackets are made of two standard brackets welded together with a single front plate to carry heavy loads.

Table 2. AEP colour codes



Standard design		Twin brackets	
Type	Colour	Type	Colour
AEP400	Red	-	
AEP600	Grey	-	
AEP800	Yellow	AEP1600	Black
AEP1100	Green	AEP2200	Blue

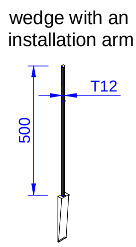


Front plates and bridge parts are painted with different colours to make it easy to control which steel part has been used in the precast element and which bridge part should the installed into the column part.

When ordering the different bracket parts should be specified according to following principles. The column steel part product code includes the number of beams to be connected in the same level. Other parts are always manufactured with standard dimensions.

Examples of different steel parts in the load range 400 kN.

AEP400PI	column part for single beam connection
AEP400S	wall part for single beam connection
AEP400PA	beam part
AEP400K	bridge part
AEP400KL	locking wedge



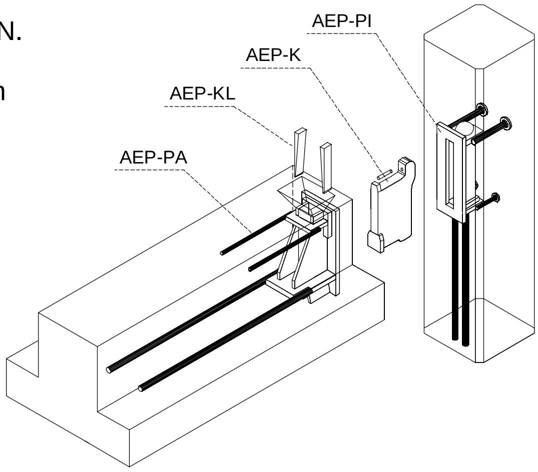


Fig 2. The AEP bracket system with including product parts

Product codes for column steel parts with several beams connected in the same level are presented in figs 8 and 9. Special versions are delivered according to customer drawings.

2. MATERIALS AND STRUCTURE

2.1 Materials

– Front plates & bridge parts	EN 10025	Grade Optim 500ML
– All other plates	EN 10025	Grade S355J2+N
– Anchor bars	EN 10080	Grade B500B

2.2 Manufacturing

Manufacturing methods:

- Plates — Mechanical cutting or cutting by flame
- Anchor bars — Mechanical cutting
- Welding — MAG welding with robot or by hand, class C EN-ISO 5817
  Rebars are welded according to EN 17660-1
- Production according to EN 1090-2: 2008

Surface treatment:

- Visible surfaces and bridge parts are painted according to standard EN ISO 12944-5 class A1.01
- On request the bracket parts can be hot dip galvanized according to EN-ISO 1461
  (1-month storage before concreting)

Manufacturing tolerances:

– Distance between two front plates:	Nominal distance - 4 mm	±2 mm
– Plate side dimensions		±2 mm
– Plate thickness		-0..+2 mm
– Anchor bar position		±5 mm
– Anchor bar length		±10 mm

2.3 AEP dimensions

2.3.1 AEP-PI column part

The AEP-PI column part is used to connect a single beam to the column. The steel part can also be used to connect two or three beams in the same level if the column cross-section is big enough for the anchor bars and the column main reinforcement. Observe the front plate position in round columns (see chapter 2.3.6).

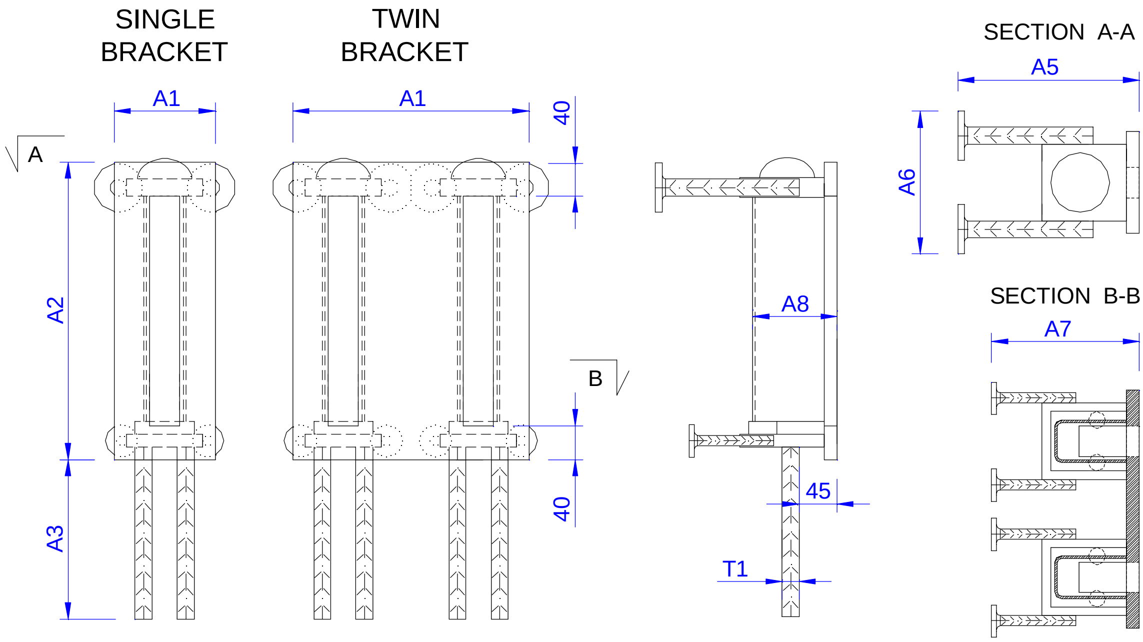


Fig 3. AEP-PI column part

Table 3. AEP-PI column part dimensions

Type	A1 mm	A2 mm	A3 mm	A5 mm	A6 mm	A7 mm	A8 mm	T1 mm	Weight kg	Colour
AEP400PI	120	240	585	210	168	170	85	1T20	7,9	Red
AEP600PI	120	310	585	215	168	175	95	2T20	11,3	Grey
AEP800PI	120	350	740	240	188	175	100	2T25	16,4	Yellow
AEP1100PI	150	390	910	250	233	180	125	2T32	29,2	Green
AEP1600PI	270	350	740	240	340	175	100	4T25	34,3	Black
AEP2200PI	340	390	910	250	420	180	125	4T32	61,0	Blue

Symbols:
A1 = Width of front plate
A2 = Height of front plate
A3 = Length of compression bars
A5 = Length of upper stud head anchors
A6 = Total width of upper anchor bars
A7 = Length of lower stud head anchors
A8 = Depth of bridge part box
T1 = Rebar diameter

2.4 AEP-PA beam part

The AEP-PA beam part can be used in prestressed or reinforced concrete beams.

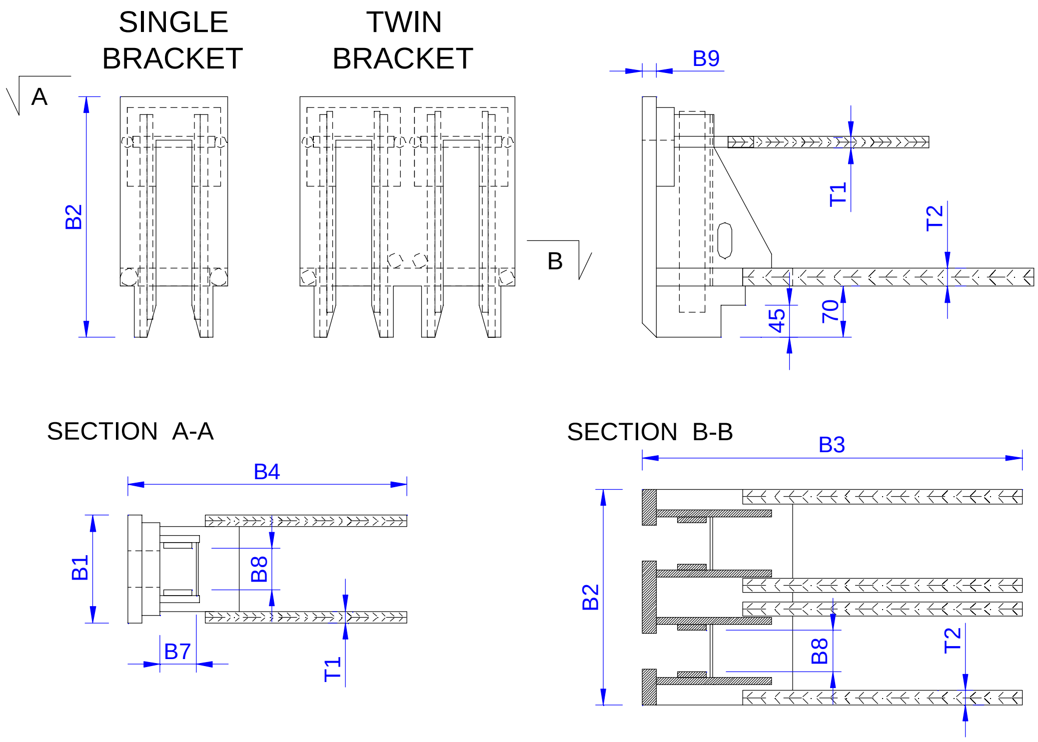


Fig 4. AEP-PA beam part

Table 4. AEP-PA beam part dimensions

Type	B1 mm	B2 mm	B3 mm	B4 mm	B7 mm	B8 mm	B9 mm	T1 mm	T2 mm	Weight kg	Colour
AEP400PA	150	215	1025	425	45	58	10	2T12	2T20	12,7	Red
AEP600PA	150	275	1035	560	45	58	15	2T16	2T20	18,8	Grey
AEP800PA	150	335	1240	670	50	58	20	2T16	2T25	29,2	Yellow
AEP1100PA	190	380	1240	640	50	73	20	2T16	2T25	39,5	Green
AEP1600PA	300	335	1240	670	50	58	20	4T16	4T25	59,6	Black
AEP2200PA	380	380	1240	640	50	73	20	4T16	4T25	92,5	Blue

Symbols:
B1 = Width of front plate
B2 = Height of front plate
B3 = Length at lower anchor bars
B4 = Length at upper anchor bars
B7 = Depth of wedge box
B8 = Width of wedge box
B9 = Front plate thickness
T1 = Upper rebar diameter
T2 = Lower rebar diameter

2.4.1 AEP-K bridge part

The dimensions of the bridge part are the same within the capacity class for all column part alternatives. In twin brackets two standard bridge parts either AEP800K or AEP1100K are used.

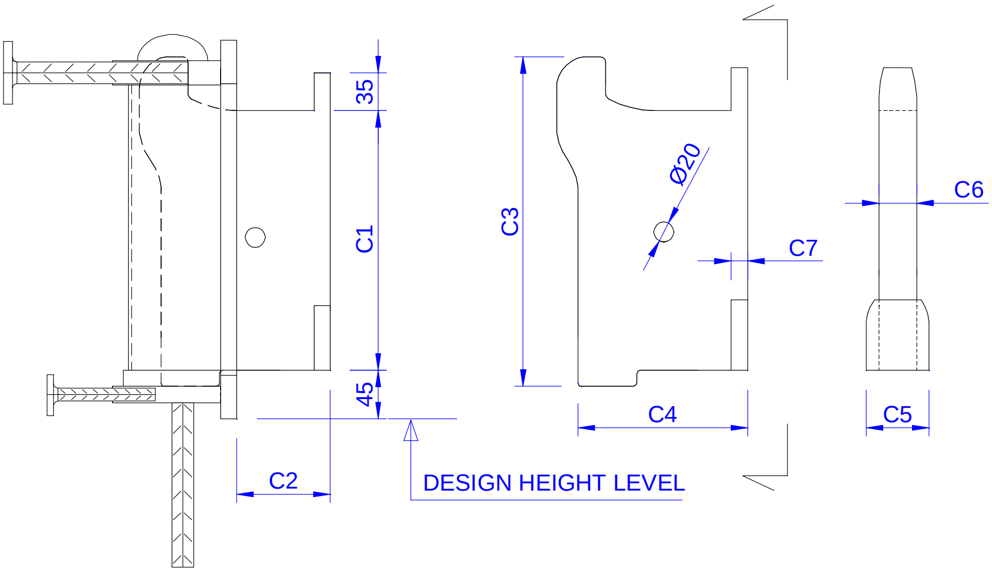


Fig 5. AEP-K bridge part

Table 5. AEP-K bridge part dimensions

Type	C1 mm	C2 mm	C3 mm	C4 mm	C5 mm	C6 mm	C7 mm	Weight kg
AEP400K	125	70	192	126	56	35	15	5,6
AEP600K	180	80	260	141	56	35	15	8,6
AEP800K	230	100	305	170	56	35	20	12,7
AEP1100K	260	100	350	180	71	50	20	22,3

Symbols:
C1 = Height in beam
C2 = Protrusion from column surface
C3 = Height in column
C4 = Bridge length
C5 = Total width
C6 = Bridge plate thickness
C7 = Supporting plate thickness

2.5 AEP-S wall part

The AEP-S wall part is a shorter version of the column standard part that can be installed in concrete walls with a minimum thickness of 180...240 mm. It can also be used in columns with concrete class C25/30 or more.

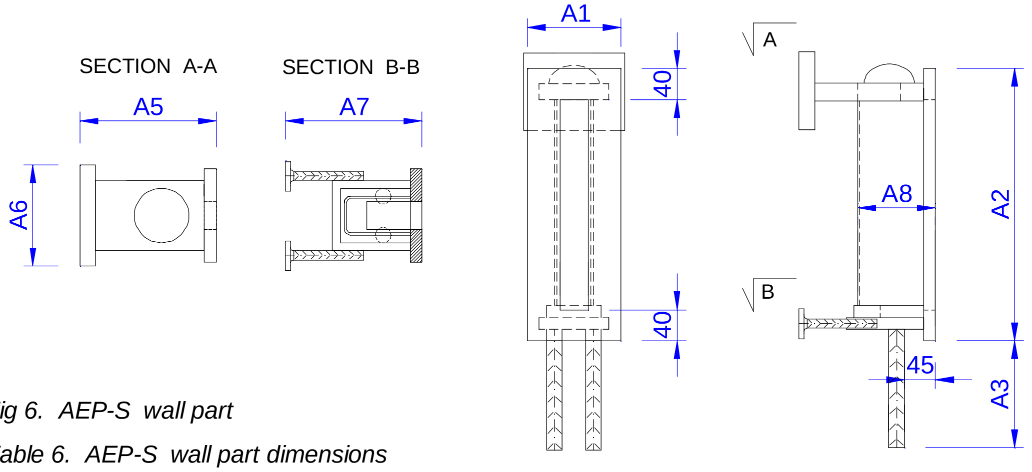


Fig 6. AEP-S wall part

Table 6. AEP-S wall part dimensions

Type	A1 mm	A2 mm	A3 mm	A5 mm	A6 mm	A7 mm	A8 mm	B mm	Weight kg
AEP400S	120	240	585	150	150	150	85	180	8,5
AEP600S	120	310	585	150	150	150	95	180	11,8
AEP800S	120	350	740	175	160	175	100	200	17,5
AEP1100S	150	390	910	215	190	180	125	240	31,3

2.5.1 AEP-PP part for beam-to-beam connection

The AEP-PP beam-to-beam part is a lower version of the standard column part to be installed in beam sides. The structure makes it possible to connect two equally heigh prefab beams in a perpendicular joint.

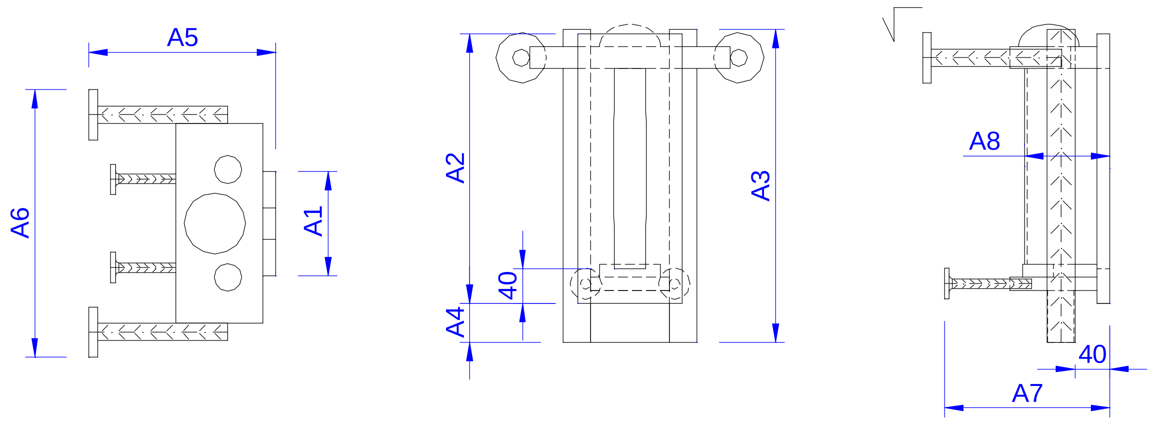


Fig 7. AEP-PP beam side part in a beam-to-beam connection

Table 7. Dimensions of AEP-PP beam-to-beam connections

Type	A1 mm	A2 mm	A3 mm	A4 mm	A5 mm	A6 mm	A7 mm	A8 mm	A9 mm	Weight kg
AEP400PP	120	240	275	35	210	280	170	85	140	10,9
AEP600PP	120	310	360	45	215	310	190	95	155	17,1
AEP800PP	120	350	425	70	240	330	190	100	155	24,1
AEP1100PP	150	390	490	90	250	385	195	125	190	40,2

2.5.2 AEP column part for connecting two opposite beams

This AEP column part is designed for connecting two opposite beams to a column in the same level. In round column the straight front plate, placed inside the cross-section, will give a smaller D1 dimension than the column diameter. The dimension D1 must be specified in order.

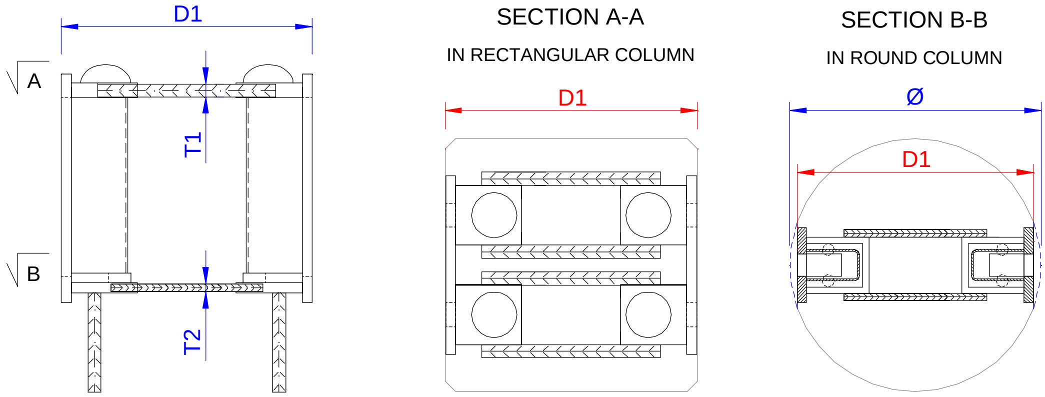


Fig 8. AEP column part for connecting two beams

Table 8. AEP column part dimensions in a two beam connection

Type	T1	T2	Immersion length (Ø – D1) in round columns					Colour
	mm	mm	Ø280-350	Ø360-450	Ø460-550	Ø560-650	Ø660-750	
AEP400PI-D1-2	2T20	2T12	30	25	20	20	15	Red
AEP600PI-D1-2	2T20	2T12	30	25	20	20	15	Grey
AEP800PI-D1-2	2T25	2T12	-	25	20	20	15	Yellow
AEP1100PI-D1-2	2T32	2T16	-	35	30	25	20	Green
AEP1600PI-D1-2	4T25	2T12	-	-	-	-	-	Black
AEP2200PI-D1-2	4T32	2T16	-	-	-	-	-	Blue

2.5.3 AEP column part for connecting several beams

This AEP column part is designed for connecting two or three beams in the same level. The steel part is welded together with customer dimensions using standard parts.

<u>3-sided column part</u>
AEP*PI–E1–E2–3**
for example:
AEP400PI–380–190–3

<u>2-sided column part in 90° angle</u>
AEP*PI–E1–E2–2**
for example:
AEP400PI–190–190–2

Special versions can also be delivered according to customer drawings in cases like:

– Column part into round column with special angle
– Several capacities in same height level
– Several parts with slightly different height level

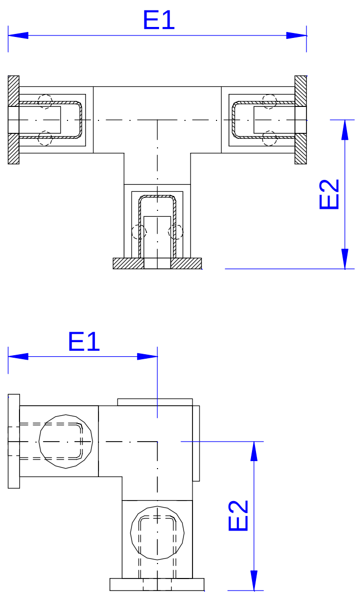


Fig 9. AEP column part for connecting two or three beams

3. QUALITY CONTROL AND MARKING

Anstar Oy has a quality control agreement with Inspecta Certification and Nordcert. The shoe production is certified according to standards EN 1090-1, EN 3834-2 and EN 17660-1.

CERTIFIED BY inspecta
ISO 9001
ISO 14001

Steel brackets are manufactured with following markings:
- control mark for Inspecta Certification and Nordcert
- company name ANSTAR, CE-mark, product type and week of manufacture

SBS CE FI

4. CONNECTION DESIGN

4.1 Basis of design

The AEP bracket connection is designed according to:
- EN 1993-1-1 Eurocode 3: Design of steel structures – general rules
- EN 1993-1-8 Eurocode 3: Design of steel structures – joints
- EN 1992-1-1 Eurocode 2: Design of concrete structures – general rules

Concrete C40/50, other than good bond conditions (EN 1992-1-1: 8.4):

$\gamma_c = 1{,}5$ $\gamma_s = 1{,}15$ rebars $\gamma_s = 1{,}0$ plates
$\alpha_3 = 0{,}7$ $\alpha_6 = 1{,}0$ $\alpha_1 = \alpha_2 = \alpha_4 = \alpha_5 = 1{,}0$
$\eta_1 = 1{,}0$ $\eta_2 = 1{,}0$

4.2 Capacity values

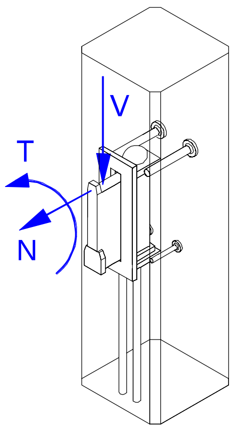
In the AEP bracket system the beam is simply supported (hinge joint). The connection transfers shear forces, torsional forces and horizontal forces from beam to column or wall. The AEP system can not be used to transfer bending moments in moment resisting knee-joints.

The capacity values for concrete C40/50 are given in table 9.

Table 9. Capacity values for the AEP bracket system in concrete C40/50

Type	Final structure[(x)]			Installation		
	V_{Rd} [kN]	T_{Rd} [kNm]	N_{Rd} [kN]	$V_{a,Rd}$ [kN]	$T_{a,Rd}$ [kNm]	$N_{a,Rd}$ [kN]
AEP400	400	10	50	200	15	100
AEP600	600	20	60	300	30	120
AEP800	800	30	80	400	50	160
AEP1100	1100	50	100	550	80	200
AEP1600[(1]	1600	60	160	800	100	320
AEP2200[(1]	2200	100	200	1100	160	400

[(1] The capacity values for twin bracket are given for centric loading. Load value of single bracket may not exceed half of whole item capacity.



Capacity values in the final structure when joint concrete has hardened
- V_{Rd} = the design value of the shear capacity
- T_{Rd} = the design value of the torsion capacity
- N_{Rd} = the design value of the horizontal tension capacity

Capacity values during installation before joint concreting
- $V_{a,Rd}$ = the design value of the shear capacity (50 % of final value)
- $T_{a,Rd}$ = the design value of the torsion capacity for internal beams
- $N_{a,Rd}$ = the design value of the horizontal tension capacity

[(x)] Capacity values for lower concrete grades are handled in chapter 5.4.

4.3 Correction of capacity values

The capacity values have been calculated for concrete C40/50. With other concrete grades the AEP system can be used according to following:
- for higher concrete grades the values in table 9 are used.
- the correction factor of AEP-PI and AEP-PA parts for lower concrete grades is based on actual

ultimate bond stress according to EN 1992-1-1: 8.4.2

$$n = f_{bd\ dim} / f_{bd\ C40/50} < 1,0$$

– The wall part (fig 6) can be used without capacity reduction for concrete grades ≥ C25/30.

4.4 Design instructions

4.4.1 Bracket position in a column-to-beam joint

1. **Concrete frame**
   It is recommended that the lower end of the beam part front plate is positioned in the same level as the beam lower surface, the lower end of the column part front plate will then also be in the same level as the beam lower surface. In high beams the bracket will be positioned higher so that the bridge part upper level is in the same level with the hollow core slabs. This way the beam hinge joint can rotate at an optimal height level. The joint between the beam and the column must allow the beam end to rotate vertically on the bridge support.

2. **Bracket with the composite A-Beam**
   With composite A-Beams the lower end of the column part front plate will be in the same level with lower surface of the hollow core deck slabs. More instructions can be found in the A-Beam product manual.

4.4.2 Design of hollow core slabs

1. **Deck stability**
   The slab elements are tied together to a monolithic floor unit by placing reinforcement in the slab joints. The bracket system cannot be used to tie the slabs together, the tying rebars must be anchored to the other side of the bracket joint. The horizontal load capacity has been determined only for installation loads and accidental loads on the final structure.

2. **Joint between beam and hollow core slabs**
   After hardening of the concrete the joint reinforcement will tie the slabs and beam together and the live load cannot therefore add to the beam torsion load. The bracket joint must still be analyzed also for the live load.

4.4.3 Checking load capacities

The load capacities given in table 9 are checked in the following manner:

1. **Beam shear load**
   The bridge part will transfer the shear load V_{Ed} to the column. The bracket type is chosen so that the design shear load V_{Ed} will not exceed the given capacity V_{Rd}.

2. **Beam horizontal load**
   The horizontal load capacity N_{Rd} has been determined for extraordinary tension loads during installation and accidental loads on the final structure. The AEP bracket system can transfer extraordinary horizontal loads also without tie reinforcement and joint concreting but cannot be used to replace the tie reinforcement.

3. **Beam torsion**
   Unsymmetrical beam loading will cause torsion that is transferred to the column. The design torsion load T_{Ed} must not exceed the given capacity T_{Rd}. The torsion capacity $T_{a,Rd}$ during installation has been raised by restricting the shear capacity to 50 % of the maximum value. This added capacity can be used only for temporary, unsymmetrical installation loads of internal beams. This torsion will be eliminated in the final structure. In edge beams the installation torsion load has to be carried also by the final structure and therefore the added torsion load cannot be used.

   The beam twisting caused by moving live loads has been considered as a constraint action. This load case must be analyzed for unsymmetrical live loads and/or long and slender structures. The torsion load capacity can be added by reducing the shear load (see table 9). The ductile joint behaviour in limit state is secured by using reinforcement according to principles described in chapter 5.3.

4. **Combined loads**
   The combined load effect need not be analyzed. The design criteria is that no singular given capacity is exceeded.

4.4.4 Installation

1. **Capacities**
The checking of capacities is done in the same manner as for the final structure. For internal beams it is possible during installation to use bigger torsion and horizontal load capacities by using only 50% of the shear load capacity.

2. **Assembly supports**
There is no need for supporting the beam flange during one sided slab installation as long as the torsion capacity is not exceeded.

3. **Assembly tolerance**
The bridge part is provided with a nose so, that the beam must be lifted 35 mm to get it off the bridge. The AEP steel part dimensions allow a longitudinal beam movement ±15 mm and a twist ±1.5 degrees around the longitudinal axis. This clearance is taken away by wedging the beam part to the bridge part before installation of slab elements.

4.5 Design of beams and columns

4.5.1 Beam design

1. **Beam span and bending**
The support is situated on the inner side of the beam part front plate. The span length is determined by the distance between the column surfaces from which the distance 2*e_1 is subtracted when the joint between the column and the beam is 20 mm (fig 13). The precast beam is designed for bending as a simply supported beam using the above mentioned span length. The main reinforcement is anchored to the beam end according to standard principles for rectangular beams and the steel part lower rebars are anchored to this main reinforcement.

2. **Beam end shear capacity**
The beam support reaction is acting on the lower support plate, which is situated 90 mm above the beam lower surface. The plate size has been determined so, that the shear load causes the concrete compression stress f_{cd}. The support reaction is transferred from the horizontal plate to the bridge part via the front plate. The effective beam cross-section is situated above the support plate. The beam effective height is d=H-90 mm and the effective width is b_{eff}. The shear reinforcement is determined according to principles for rectangular concrete beams (fig 10). If the bracket is positioned higher up in the beam then the shear capacity and the shear reinforcement should be designed using methods developed for recessed beam ends.

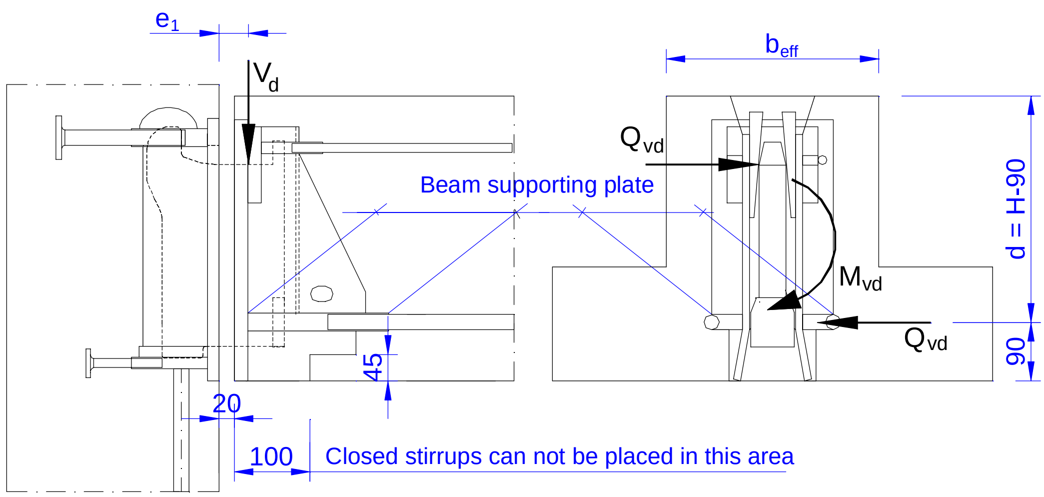


Fig 10. Forces acting on the beam part

3. **Torsion**
The AEP bracket system transfers the beam torsion to the column. If beam minimum width dimensions according to table 11 in chapter 5.2 and torsion reinforcement according to chapter 5.3.2 are used then there is no further need to analyze the internal torsion forces acting in the beam end.

The reinforcement is designed according to standard methods developed for rectangular concrete beams. Longitudinal torsion rebars must be taken to beam end and anchored using U-formed vertical links.

When designing stirrups it should be noticed that closed stirrups can be used only beginning at 100 mm from the beam end because of the bridge opening.

4.5.2 Column design

1. **Column bending moment M_{Ed}**
The shear span e_1 causes a bending moment in the column. The bridge part transfers the support reaction to the column part lower plate with the welded compression rebars (fig 14).

The column bending moment is

$$M_{Ed} = V_{Ed} * (H/2+e_1)$$

where

H = column dimension in beam direction
e_1 = shear span e_1 (see table 14)
V_{Ed} = Total beam support reaction for one beam connections. The difference between maximum and minimum support reactions from opposite column sides in double beam connections. The critical design combination is calculated for both assembly and final structure.

The column main reinforcement is checked for this eccentricity moment M_{Ed}.

Table 10. Bracket dimensions for column design

Type	p_1	e_1
AEP400	185	45
AEP600	250	50
AEP800	295	50
AEP1100	340	55
AEP1600	295	50
AEP2200	340	55

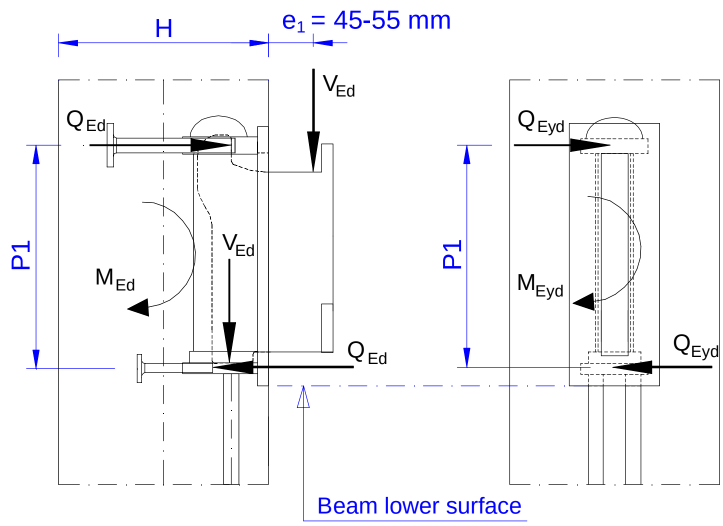


Fig 11. Forces acting on the column part

2. **Shear force caused by the moment M_{Ed}**
The bending moment M_{Ed} causes a force couple with shear load Q_{Ed} (fig 11).

$$Q_{Ed} = M_{Ed}/p_1$$

where dimension p_1 is given in table 10.
The column is provided with stirrups A_{sw} according to chapter 5.3.1.

3. **Torsion T_{Ed}**
The torsional moment T_{Ed} transferred from the beam causes a local bending moment at the column steel part.

$$M_{Eyd} = T_{Ed}$$

This moment causes a force couple with shear load Q_{Eyd}

$$Q_{Eyd} = M_{Eyd}/p_1,$$

where p_1 is taken from table 10
The needed strirrups are included in the additional reinforcement A_{SW} in chapter 5.3.1. The column main reinforcement must be checked for the bending moment M_{Eyd}.

4. **Cross-section reduction**
   There is no need for a cross-section reduction because of the bridge box, since the vertical steel plates carry the necessary compression load.

5. **Column reinforcement**
   The column reinforcement is designed according to standard methods, the only addition is the checking of the eccentricity moments. The stirrups are designed according to chapter 5.3.1. Observe that closed stirrups can not be used at the bridge box.

5. USING THE AEP BRACKET

5.1 Limitations on use

The capacities have been determined for static loads only. Loads including dynamic effects are taken into account according to EN 1990-1, Section 4.1.5, with the corresponding increased partial safety factors for loads. Earthquake is taken into account in the load combination according to EN 1991-1[5]. The partial safety factor level is selected in accordance with the European standard.

The AEP bracket system can be used in precast concrete framed structures and with composite concrete-steel columns and the Anstar composite A-Beam. The use of the AEP bracket system together with other composite or steel beams must be examined in each case.

The bracket system can not be used in moment resisting connections and the bracket should always be designed in such a manner that no fixing moments are transferred. The joint between the beam and the column must allow the beam end to rotate vertically on the bridge support.

The use of the given capacity values requires that the assembly tolerances are according to chapter 6.4 and that the additional reinforcement is according to chapter 5.3.

5.2 Minimum structural dimensions

The structural minimum dimensions have been determined for a centric bracket in fire resistance class R120. Minimum dimensions for beams are given in table 11 and fig 12. The minimum width B_{min} has been determined for a load case without torsion and the minimum width B_T for a beam transferring the bracket torsion capacity. When placing prestressing tendons around the beam steel part, there might be a need to use bigger beam widths. In beam-to-beam connections the front plate distance from the beam lower surface should be at least the dimension E to allow rebar placing below the steel part.

Table 11. Minimum beam dimensions

Type	Colum-to-beam connection			Beam-to-beam connection		
	H	B_{min}	B_T	H	A	E
AEP400	300	240	280	400	280	80
AEP600	320	240	280	420	280	90
AEP800	380	280	380	500	320	110
AEP1100	420	320	480	550	340	120
AEP1600	380	380	480	-	-	-
AEP2200	420	480	580	-	-	-

B_{min} = Minimum width without torsion
B_T = Minimum width with full torsion capacity

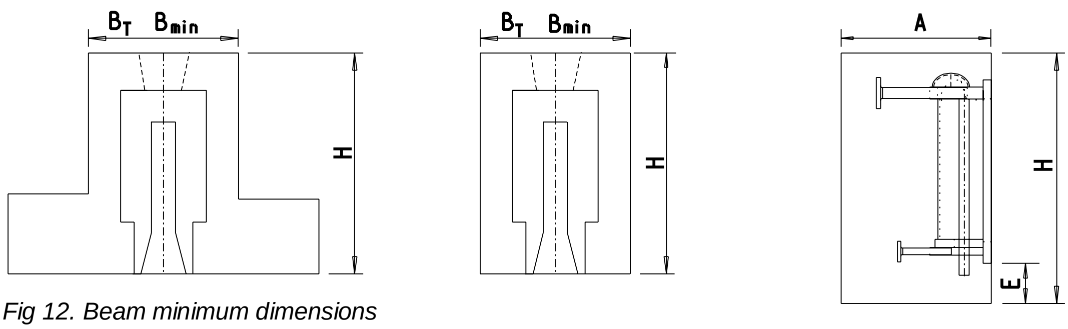


Fig 12. Beam minimum dimensions

The minimum column and wall dimensions for a single beam connection and for a twin beam connection on opposite column sides are given in table 12 for both rectangular and round columns. The distance between the front plate lower end and the column top should be at least the dimension B1 to allow placing of necessary stirrups above the bracket.

Table 12. Minimum column and wall dimensions

Type	One beam joint			Twin beam joint			Column	Wall joint	
	H	B	D	H	B	D	B1	B	E
AEP400	280	280	300	280	280	280	380	180	140
AEP600	280	280	300	280	280	280	380	180	140
AEP800	300	300	320	280	300	300	400	200	140
AEP1100	340	340	340	300	300	340	480	240	190
AEP1600	380	440	-	280	440	-	480	200	220
AEP2200	380	480	-	300	480	-	480	240	280

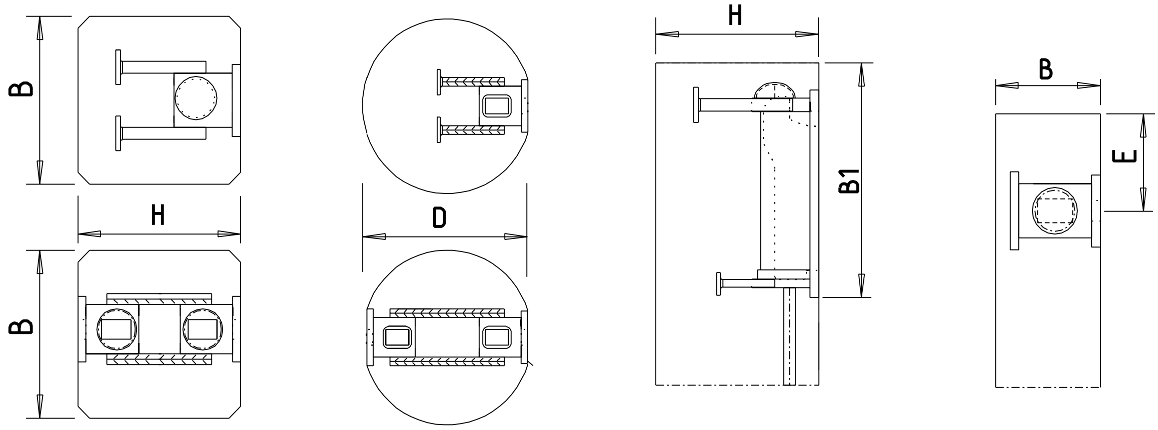


Fig13. Column and wall minimum dimensions

5.3 Additional reinforcement

5.3.1 Column

Additional stirrups are placed in the column to transfer the bracket loads and secure a ductile behaviour in limit state. Stirrups A_{sw} according to table 13 and fig 14 section A-A are placed on both sides of the column part. The stirrups are used to transfer all three loads in the same time and the stirrup amount is designed according to following instructions:

1. **Shear and torsion stirrups A_{SW}**
   The additional stirrups A_{sw} on both sides of the column part are designed to transfer shear and horizontal forces. The torsion forces act on different legs of the stirrups, which means that there is no need to add stirrups because of the torsion. The stirrups A_{sw} are placed according to following principles:
   - In a one beam joint the stirrups A_{sw} are according to table 13
   - In a twin beam joint on opposite sides of the column the stirrup amount A_{sw} is the same as for a one beam joint
   - With heavy duty parts AEP1600 and AEP2200 the stirrups are placed directly to the added vertical rebars placed close to the column part according to fig 14 section D-D
   - Also the standard column part for a one beam joint is reinforced according to section D-D in big column cross-sections because the stirrup distance from front plate edge may not exceed 120 mm. In twin brackets on opposite column sides the additional stirrups can be placed with the column standard stirrups.

   The needed additional reinforcement is added to the main reinforcement and the total reinforcement is placed in the column in the most practical way.

2. **Stirrups at the bridge box**
   Closed stirrups cannot be placed at the bridge box therefore the main rebars are tied diagonally

according to fig 14 section B-B. It is also possible to use a closed stirrup welded to the steel part. The stirrups are designed according to concrete code regulations concerning the transverse reinforcement.

3. **Stirrups at the compression rebars**
   The column part compression bars are tied together with stirrups below the column part front plate. The stirrups are designed according to concrete code regulations concerning the transverse reinforcement but there should be at least two stirrups in the compression bar middle area according to fig 14 section C-C.

Table 13. Additional column stirrups

Type	Stirrups A_{sw} mm^2	Stirrup amount
AEP400PI	276	6T8
AEP600PI	344	7T8
AEP800PI	498	7T10
AEP1100PI	542	7T10
AEP1600PI	996	9T12
AEP2200PI	1084	10T12

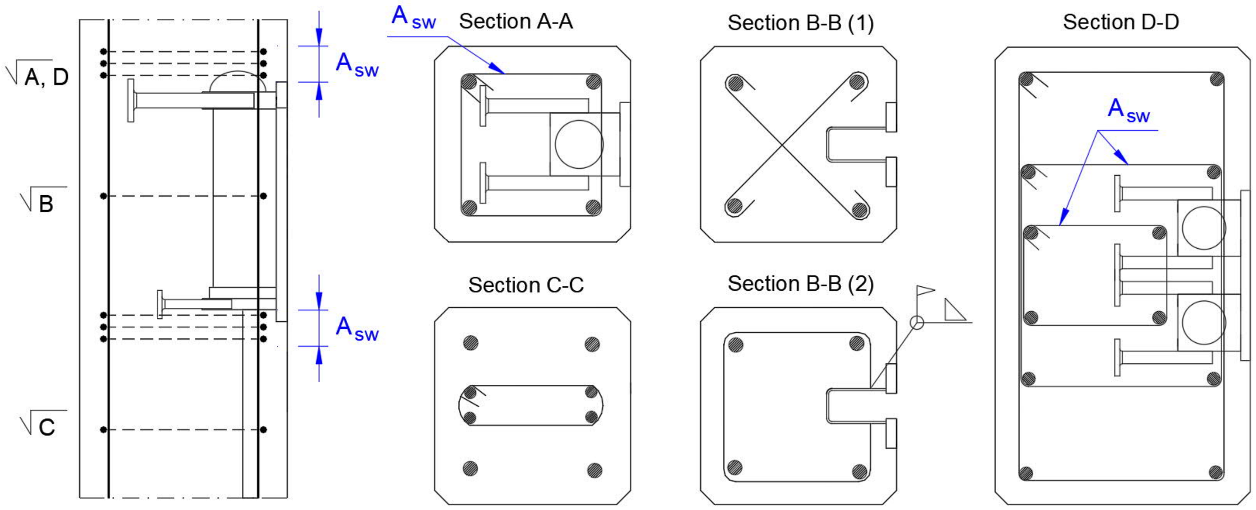


Fig 14. Column part reinforcement

5.3.2 Beam

1. **Shear capacity**
   The beam shear reinforcement is designed according to principles for rectangular concrete beams by considering the effective cross-section described in chapter 4.4.1. The beam main reinforcement is anchored to the beam end by using links (fig 15). In high beams the bracket is situated higher in the cross-section and therefore the shear reinforcement is designed according to methods developed for recessed beam ends.

2. **Torsion capacity**
   The torsion stirrups A_{sw} are placed close behind the beam support plate according to fig 15. The stirrups are determined for the bracket torsion capacity and minimum beam width B_T given in chapter 5.2. It is recommended that these stirrups are used also when the torsion capacity is not in full use to secure the ductile behaviour for unexpected moving live loads.

   Longitudinal torsion rebars are taken to the beam end and anchored using U-formed vertical links. For flange beam stirrups there is a hole above the beam part support plate, which is suited for flange height 150 mm. The same hole can also be used for flange height 100 mm by modifying the stirrups.

3. **Rebar splicing and splitting forces**
   The beam part anchoring bars have to be spliced with the main reinforcement. The transverse reinforcement is designed according to EN 1992-1-1 chapter 8.7.4.1.

Table 14. Additional beam part stirrups

Type	Stirrups A_{sw} mm^2	Stirrup amount
AEP400PA	220	3T10
AEP600PA	314	4T10
AEP800PA	370	5T10
AEP1100PA	525	7T10
AEP1600PA	740	10T10
AEP2200PA	1050	10T12

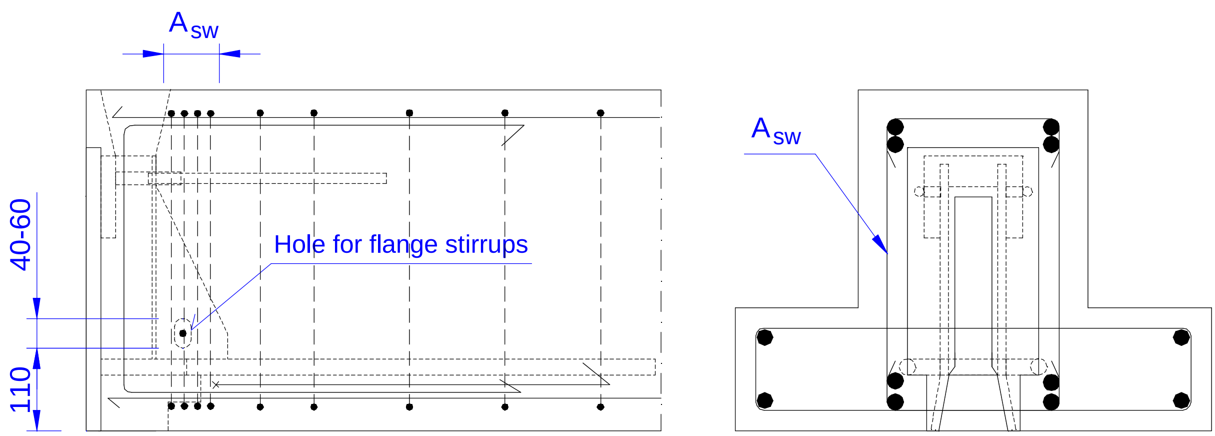


Fig 15. Beam part reinforcement

5.3.3 Wall

The forces caused by the shear span are transferred to the wall by using horizontal rebars A_{sw} according to fig 16 and table 13. To transfer the eccentricity M_{Ed} a beam strip is designed into the wall according to fig 16. If the bracket is situated at the wall vertical end surface then stirrups instructions for columns are used. The reinforcement A_{sw} is placed above and below the wall steel part.

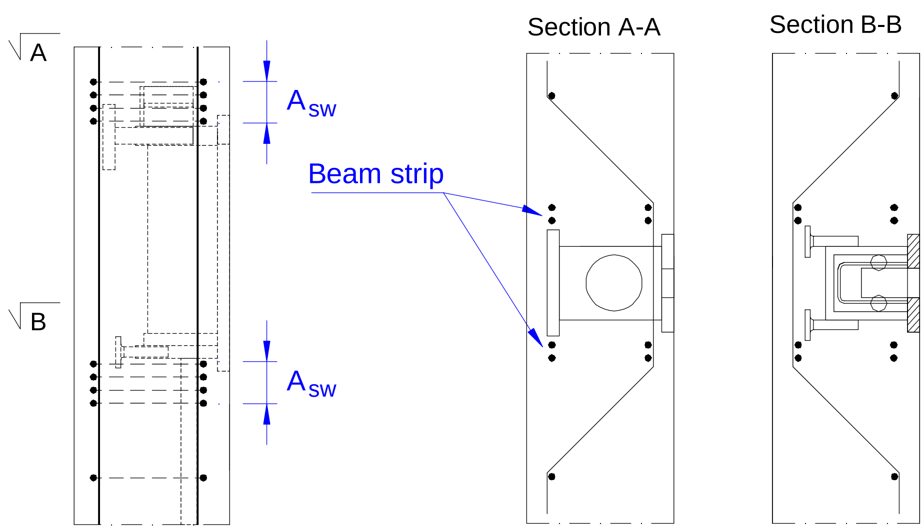


Fig 16. Wall part reinforcement

5.3.4 Beam-to-beam connection

In beam-to-beam connections the beam part AEP-PA is reinforced as in fig 15. The 'column' part AEP-PP in the main beam is reinforced according to fig 17 and table 13. The additional reinforcement A_{sw} is placed on both sides of the steel part. Extra stirrups are placed close to the upper stud anchors to prevent concrete cone failure. High wall like beams can also be reinforced according to fig 16. The main beam shear force has to be considered as for standard point loaded rectangular concrete beams.

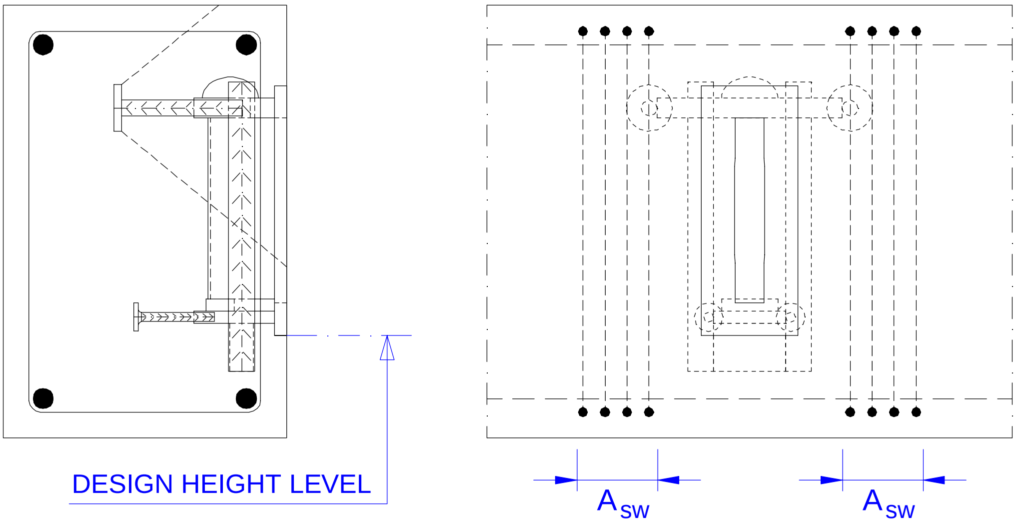


Fig 17. Beam-to-beam joint reinforcement

5.4 Fire protection

The AEP bracket steel parts are cast into concrete, which protects against fire. The rebar concrete cover is at least 45 mm, which corresponds to fire resistance class R120. On request the AEP column part rebars can be placed with a bigger concrete cover for resistance class R180. The beam part open end and the bridge box require a fire protection according to instructions in chapter 6.5.

5.5 Drawing instructions

The grip point in making drawings is the beam lower surface or the lower surface of hollow core slabs when using the composite A-Beam.

1. **Beam part**
   The beam part is placed at the beam end in the middle of the web. The bracket design height level is at the the centre of the front plate lower edge (fig 18).

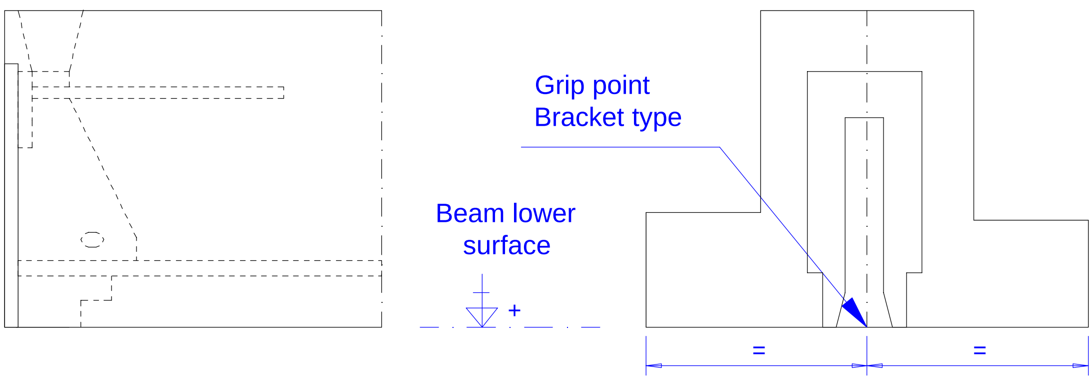


Fig 18. Drawing specification for AEP beam part

2. **Column part**
The front plate is at the column surface and the the height level is defined by the plate lower edge similar to the beam front plate (fig 19).

If the beam part is placed higher in the beam cross-section the column part height level will follow to the same height level. Sideways the grip point is always the beam and column centre lines.

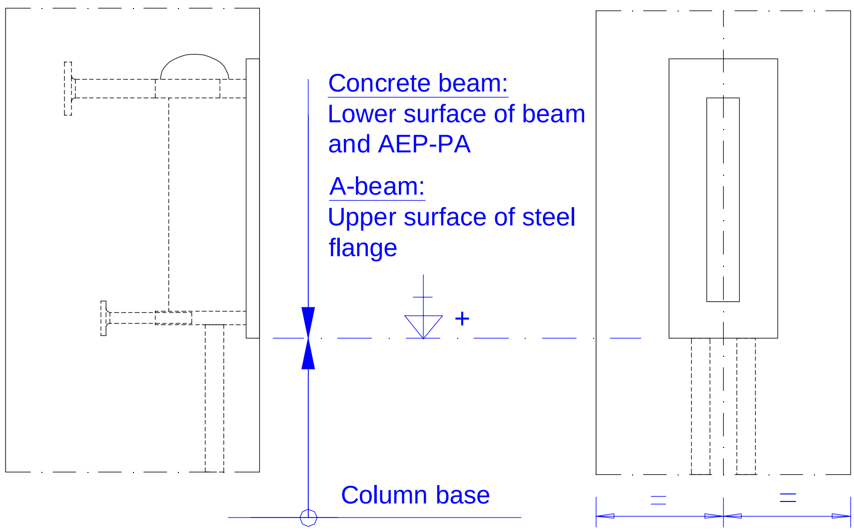


Fig 19. Drawing specification for the AEP column part

5.6 Placing steel parts into mould

The steel parts must be embedded properly into the concrete. To get a good casting result the casting direction should be considered and the concrete should be compacted layer by layer.

1. **Beam part**
The beam part is placed on the mould bottom and fixed to the mould end plate. First the beam flanges and the part below the beam support plate is cast and then the upper part is filled with concrete.

2. **Column part**
The column can be cast in a horizontal or a vertical mould. In vertical moulds it is important to secure that the column part lower plate is embedded properly into the concrete. In horizontal moulds the column part can be fixed to the mould bottom or the mould sides.

5.7 Placing prestressing tendons

The position of the beam steel parts must be considered in prestressed beams. Tendons can be placed according to fig 20. Tendons in the bridge box area should be cut at the back of the box to avoid assembly problems on site. More information can be found from Anstar home pages.

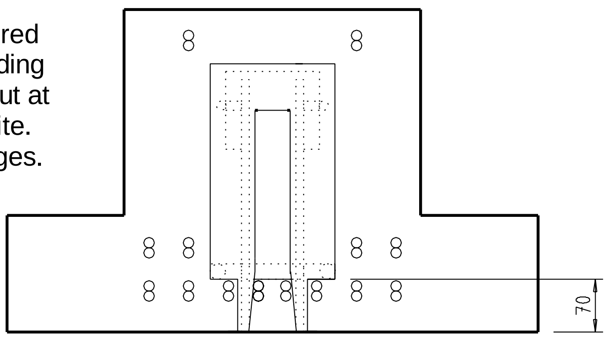


Fig 20. Placing prestressing tendons

5.8 Design working life and durability

The AEP steel bracket durability is designed according to EN 1992-1-1 (2004) chapter 4. The same exposure class is chosen for the bracket as for the building frame, if there is no special need for using a higher class.

1. **Concrete cover of rebars**
   The concrete cover of column part rebars is 45 mm and of beam part lower rebars 70 mm. The concrete cover of the whole reinforcement is chosen according to exposure class and design working life. When needed the bracket assembly tolerance is considered in the allowable cover tolerance.

2. **Exposure class for steel plates**
   The surface treatment and the placing of the steel parts are chosen according to the exposure class:

   Exposure class X0:
   The surface treatment of steel plates in dry and warm inside structures is EN-ISO 12944-5 S2.1 (workshop primer A40/1), which gives protection during transport and assembly

   Exposure classes XC 1...4:
   The leakage of water into the connection must be prevented. The surface treatment of visible steel parts is decided for each project.

   In cold and damp conditions the steel parts are hot-dip galvanized. The galvanized parts are kept in stock at least for one month, this way the zinc coating will be oxidized and the chemical reaction between cement and zinc during concrete casting is eliminated.

   Exposure classes XD 1..3, XS 1...3:
   The possible use of hot-dip galvanized steel parts should be checked for each project. The leakage of water into the connection must be prevented by structural means.

6. BRACKET ASSEMBLY

6.1 Fixing parts into mould

1. **Fixing column parts**
   The front plate is fixed tightly against the mould side or bottom so, that the concrete casting does not affect the correct position. Placing on top of mould should be avoided because reaching the tolerance requirements gets then much harder. The additional reinforcement is placed and the column part is ready for concrete casting. The correct column part position is essential for easy assembly on site.

   The bridge box opening should be closed with tape before fixing the front plate to the mould to avoid cement paste from getting into the box.

2. **Fixing beam parts**
   The front plate is placed on the mould bottom and fixed tightly against the mould end plate so, that the correct position is kept during the concrete casting. Steel parts in correct position are essential for easy assembly on site.

   Above the beam part a recess should be made for the wedging. The recess bottom should be at least the same size as the wedge box opening and the sides should become wider upwards to make the wedge assembly easy. When needed assembly parts can be welded to the steel plates. The tendon opening at the back of the bridge box is closed in a suitable manner.

3. **Fixing bridge parts**
   The bridge part is delivered to the pecast plant together with the column parts. After demoulding the bridge part is placed into the bridge box and locked with a tube pin to secure the correct position during transport and assembly.

   The bridge top 1 is lifted into the column part bridge box 2 as long as it goes (fig 21). The bridge part is turned into the box and lowered to its final position with bridge lower part 3 resting on the support plate 4. In the correct position the distance between the front plate lower side and the bridge part lower edge is 45 mm. The bridge upper part is locked with a tube pin 5. The bridge can be disengaged by loosening the pin, lifting the bridge part up and turning it outwards.

4. **Fixing tolerances**
   Beam part
   The beam part front plate is placed on the mould bottom and fixed tightly against the mould end plate. The fixing tolerances with measurements from the front plate centre line are:
   – Sideway distance from beam centre line ± 5 mm
   – Height measured from mould bottom ± 5 mm
   – Front plate total inclination from vertical line (both directions) ± 2 mm

   Column part
   The column part front plate is fixed tightly against the mould side. The fixing tolerances with measurements from the front plate centre line are:
   – Sideway distance from column centre line ± 5 mm
   – Height position ± 5 mm
   – Front plate rotation in plane measured from the plate corners ± 2 mm
   – The distance between the front plates in a two beam connection is manufactured with the tolerance - 4 mm to guarantee that the part fits into the column mould.

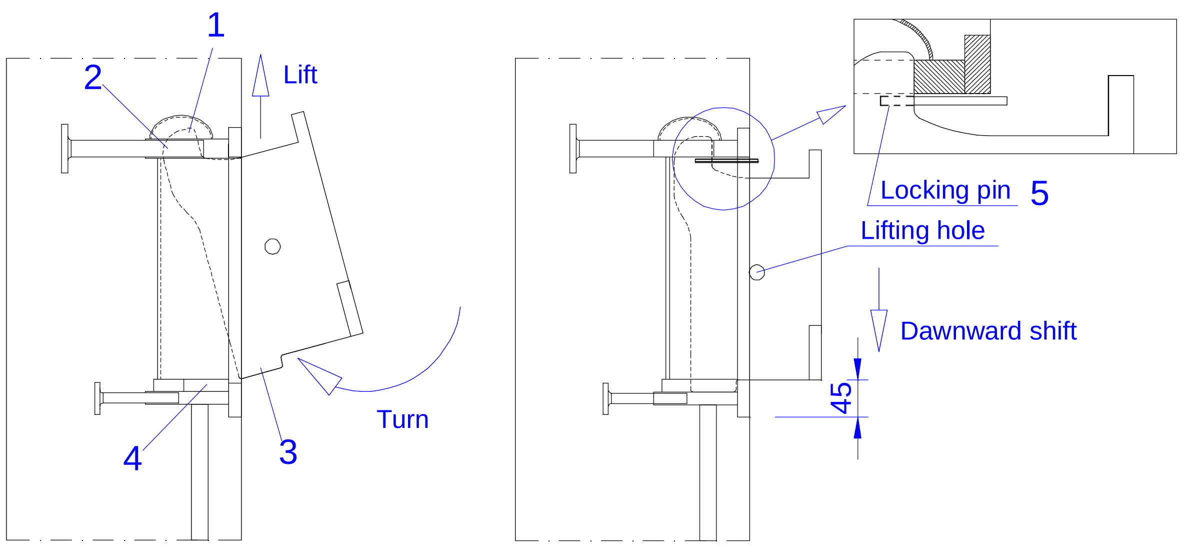


Fig 21. Bridge part installation

6.2 Assembly on site

1. **Beam assembly**
   The bridge part may not be used for any kind of column lifting operations. The beam is lifted above the bridge part so, that the beam opening is in line with the bridge. The beam is then lowered so, that the whole bridge goes into the beam opening (fig 22).

   After the assembly the support surface of the beam front plate lies on the bridge part. In the correct position the distance between the lower sides of the bridge and the front plate is 45 mm.

   The precast beam is now safely on the bracket and the lifting devices can be removed. Usually the nominal joint between column and beam is 20 mm. Before wedging the beam is pushed longitudinally so, that the joints on both ends are equal.

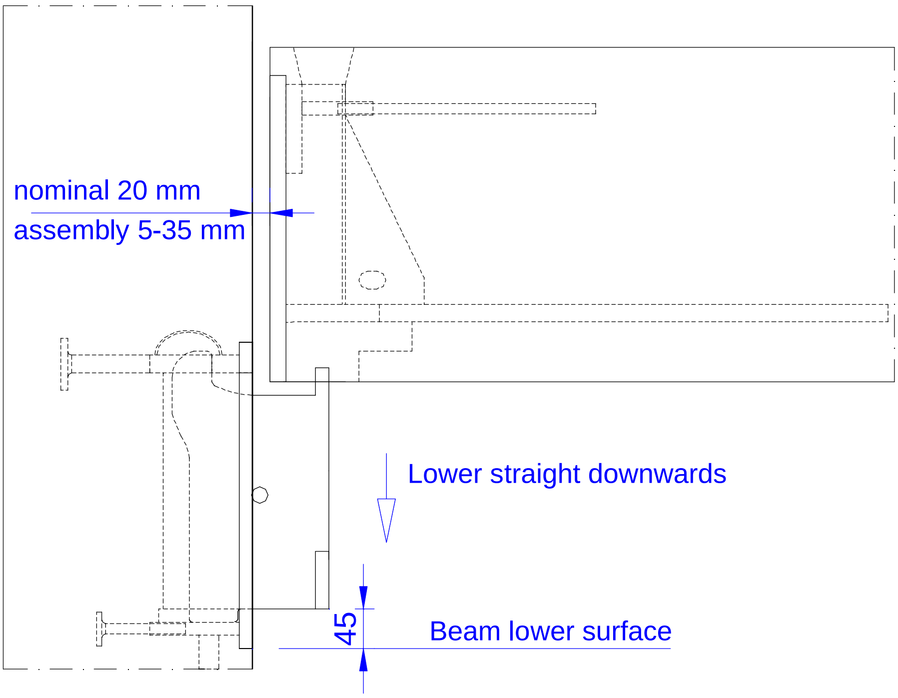


Fig 22. Beam assembly on bracket

2. **Locking the connection with wedges**
   The beam inclination on the bracket can be adjusted by using the wedge parts AEP-KL, which locks the connection so, that it can transfer torsion forces. The wedges are put into the recess and clamped on both sides of the bridge. In high beams wedges with an installation arm AEP-VKL can be used. When needed the arm is cut before casting of the topping screed.

   When needed the nominal joint 20 mm between the column and beam end can be adjusted before the wedges are clamped. The beam inclination can be controlled with the wedges, using only one wedge will incline the beam. The wedges are clamped by hitting them lightly in turns so, that the desired beam inclination is reached. The edge beam inclination caused by the unsymmetrical loading can be compensated by clamping the beam into an opposite position. After clamping the beam is ready for assembly of deck slabs (fig 23).

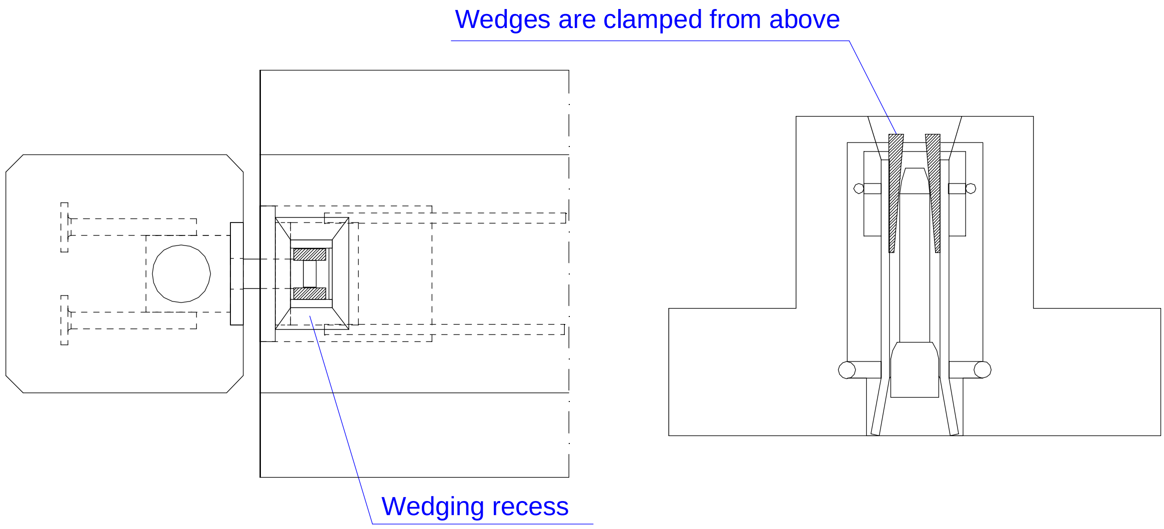


Fig 23. Locking the connection with wedges

3. **Assembly of deck slabs**
   The torsion forces can be minimized by placing slabs in turns on both beam sides. The designed installation order must be followed so, that the torsion capacity will not be exceeded.

4. **Supporting the beam during slab installation**
   The AEP bracket system transfers torsion loads caused by unsymmetrical slab installation. Usually there is no need for supporting the beam if the beam has been designed to carry the torsion load. Beam supports are needed in the following cases:
   – The torsion load exceeds the connection capacity
   – The column is too slender to carry the torsion load
   – The beam has not been designed to carry the installation torsion load
   The support instructions are given in the frame installation design.

6.3 Assembly tolerances

The AEP bracket system has been designed for precast manufacturing tolerances recommended by the Finnish concrete industry.

1. **Beam longitudinal direction**
   With the nominal joint 20 mm between column and beam end the connection tolerance for the beam horizontal position is ±15 mm. The joint size can then vary between 5...35 mm. During installation the beam position is locked with the wedges and in the final structure with the slab tie reinforcement.

2. **Beam sideway direction**
   Sideways the beam position can be corrected about 8 mm by using internal control plates on the bridge box side plates. The control plate is disengaged from the box plate by hitting on it and then welded to the other side of the bridge box.

3. **Beam height level**
   The height level can be corrected by actions described in chapter 6.4.

4. **Beam inclination in relation to its longitudinal axis**
   The bracket dimensions allow an inclination ± 1.5˚in relation to the beam longitudinal axis. This corresponds to the concrete industry manufacturing tolerances. During installation the beam can be clamped to an inclination that corrects the installation and/or manufacturing tolerances. The clamping with wedges locks the beam position.

5. **Column inclination in relation to its longitudinal axis**
   The column bridge box allows an inclination ± 2˚ in relation to the column longitudinal axis and this tolerance does not affect on the beam installation.

6.4 Actions when tolerances are exceeded

1. **Beam longitudinal tolerance**
   If the beam longitudinal tolerance is exceeded the only way to correct the situation is to manufacture a longer bridge part, which means that the capacity values must be checked with new calculations.

2. **Beam height tolerance**
   The beam height level can be corrected +20, -25 mm. If the column part is placed too low the bridge part can be provided with a filler plate S355 t ≤ 20 mm and the beam is assembled on this plate (fig 24). If the column part is too high a notch ≤ 25 mm can be cut to the bridge support surface (fig 24).

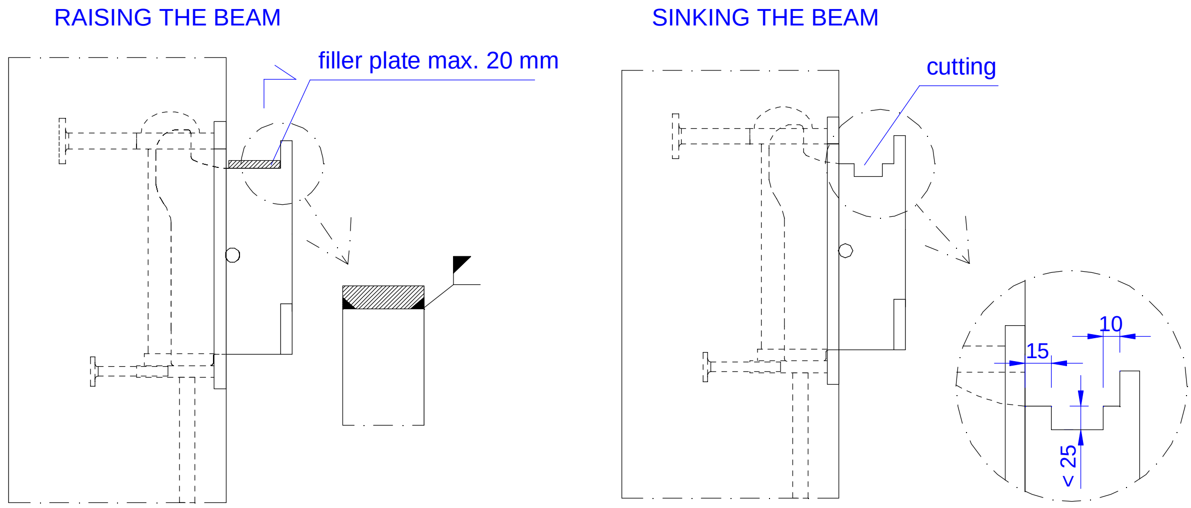


Fig 24. Adjusting height level

These changes do not have an influence on the connection capacity values. When bigger corrections are needed a special bridge part will be produced and new capacity values will be calculated.

3. **Beam inclination tolerance**
   The correction is done by disengaging one of the internal control plates from the box side, which gives some more adjusting space. A piece of the bridge lower support plate is cut off so, that the needed inclination can be reached. This does not influence the connection shear capacity but the torsion capacity is lost and the beam must now be supported during assembly.

6.5 Safety precautions

1. **Actions at the precast plant:**
   - The bridge part may not be used for any kind of lifting operations
   - It is not allowed to bend or cut the steel parts when fixing them into the mould. The anchor bars can be welded when fixing into mould.

2. **Actions on site**
   - The concrete strength must be according to plan before starting of assembly.
   - The installation order and the use of supports should be according to plan.
   - If slabs are installed on supported beam flanges, the strength of the joint grout should be according to design before removing the supports.
   - The deck slabs may not be loaded with extra equipment or materials, before the tie reinforcement is effective in the hardened joints.
   - Actions for correcting tolerance exceedings may be taken only after approval of the designer or the bracket manufacturer.
   - The bridge part is so heavy, that it is recommended to handle it with lifting devices and using the lifting hole.

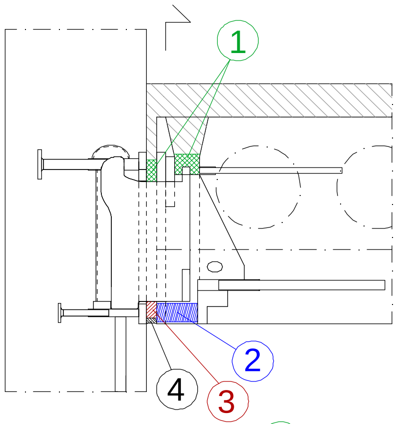
6.6 Fire protection

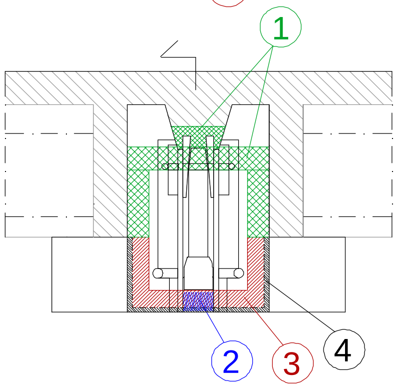
The AEP joint can be fire protected up to fire resistance class R120 using approved products as follows:

1. Using rock wool or fire protection board.
2. Using fire protection mortar, acrylic or foam.

The joint between the beam and the column must allow the beam end rotation on the bridge part. Hereby the sealants below this level must be flexible.

6.6.1 Using rock wool or fire protection board





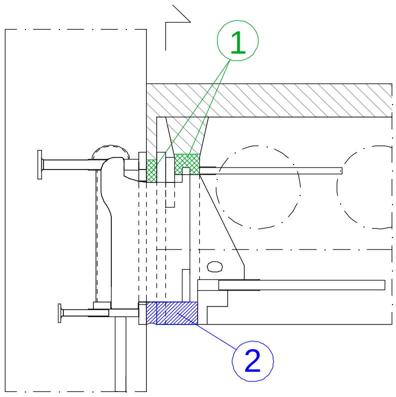
1. Rock wool or joint foam is put above the bridge part, in the wedge recess and in the vertical gab between beam and deck slab to prevent the joint grout from getting into the bridge box and column-to-beam gab. After this the slab joints and the topping can be concreted.

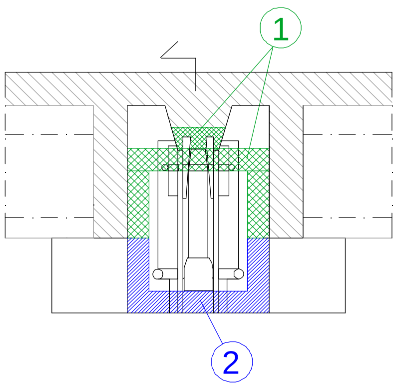
2. The beam bridge opening is closed with sertified rock wool or fire protection board. Fixing according to manufacturer's instructions using glue, firestop acrylic or welding spike.

3. Rock wool is placed in the column-to-beam horizontal gab up to console bridge part. Similarly the vertical gabs exposed to fire are wooled.

4. Rock wool is covered with flexible firestop sealant.

6.6.2 Using fire protection mortar, acrylic or foam





1. Rock wool or joint foam is put above the bridge part, in the wedge recess and in the vertical gab between beam and deck slab to prevent the joint grout from getting into the bridge box and column-to-beam gab. After this the slab joints and the topping can be concreted.

2. With the chosen material is fire protected:
   - the beam bridge opening
   - the column-to-beam horizontal gab below the bridge part
   - the vertical gabs exposed to fire

7. CONTROL PROCEDURES

7.1 Instructions for precasting

1. Before concrete casting:

- Check that the correct steel part (type, dimensions) is according to plan and that the parts are undamaged.
- Check that the additional reinforcement has been placed according to plan.
- Beam part:
  Check that the front plate is fixed tightly against the mould bottom and mould end plate and that the front plate is perpendicular to the bottom line.
  Check that the wedge recess is firmly fixed and that the bridge box has been closed below the supporting plate.
- Column part:
  Check that the front plate is fixed tightly against the column mould.
  Check that the steel part has been fixed in the correct position and the the front plate is in line with the mould side.

2. After demoulding:

- Check the concrete quality at the bracket and that the bidge boxes are clean.
- Check that the steel parts are according to given tolerances (measure height level, position from centre line and front plate inclination).

3. Bridge part assembly:

- Check that the bridge part has been assembled according to plan and that it has been locked with the tube pin.

7.2 Instructions for assembly on site

The installation is done according to the designer’s installation plan. Check list for the installation controller:

- The installation is done in planned order.
- The column and beam supports are according to plan.
- The deck slabs are assembled according to plan.
- The bridge part has been wedged in the correct manner and the longitudinal beam tolerances have been considered in the column-to-beam joints
- The fire protection has been done according to given instructions.

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